— EXHIBIT 2 —

U.S. DISTRICT COURT
WESTERN DISTRICT OF WASHINGTON

JACOB BEATY and JESSICA BEATY, on behalf of themselves and all others similarly situated, Plaintiffs, vs. FORD MOTOR COMPANY, Defendant.	Case No. 3:17-v-05201 RBL

REBUTTAL REPORT OF THOMAS READ

July 10, 2019

I. INTRODUCTION

My original report was submitted on February 13, 2019. In it I described thermally tempered glass, glass failure analysis and summarized my opinions. None of my general opinions stated in the initial report have changed. The purpose of the present report is to provide additional support for my opinions and to respond to the claims made by Ford's experts in recent reports.

II. MATERIALS REVIEWED

The resources used for this second report include both the resources relied upon for my initial report and those additional items listed below:

1. Verghese Report Dated May 24, 2019.
2. Taylor Report Dated May 24, 2019.
3. Carhart Report Dated May 24, 2019.
4. Padmanaban Report Dated May 24, 2019.
5. McCrary Report Dated May 24, 2019.
6. Survey of Ford Panoramic Sun Roofs.
7. Deposition Transcript of Verghese
8. Deposition Transcript of Taylor
9. Deposition Transcript of Carhart

III. BACKGROUND AND QUALIFICATIONS

My opinions described herein are established to a reasonable degree of scientific certainty, and are based, in part, on my extensive, firsthand knowledge and examination of panoramic sunroofs ("PSRs") that are identical in all material respects to the PSRs in the Subject Vehicles. My opinions are further based upon my education, training and multiple decades of experience in Materials Science and Engineering, and my more than forty years of conducting glass failure analyses.

As detailed in my previous report, only a portion of which is restated here, my involvement in working with glass, including tempered glass, glass failure analysis, and related subjects, began in 1972 at Corning Glass Works, where I developed the finishing processes for glass computer disks and windows for the NASA Space Shuttle, and performed glass failure analyses regarding the same. Over the span of my decades-long career studying glass, I have performed hundreds of glass failure analyses, including tempered glass failures. In addition, I have been qualified to testify in trial as an expert in failure analysis at least forty times.

In the present action, I have applied my knowledge, skill and experience with glass and glass failure analysis, which spans back to the 1970s, to evaluating the PSRs in the Subject Vehicles. This includes well-established and undisputed scientific knowledge regarding glass construction and failure, which applies to glass used in PSRs in general, the glass used in the PSRs in the Subject Vehicles'

specifically, the uniform PSR glass design in the Subject Vehicles, and the common defect in this uniform design.

IV. SUMMARY OF ARGUMENT

- During my career, I have personally examined and performed glass failure analyses on approximately twenty PSRs that are identical in all *material* respects to the panoramic sunroofs in the Subject Vehicles. These PSRs were made by Webasto and Inalfa, which supply panoramic sunroof assemblies to automobile manufacturers. Ford, like other automobile manufactures, does not manufacture PSR assemblies. When Ford receives these assemblies from the manufacturer, it simply attaches them to the automobile body. The construction and functionality of the PSR assemblies does not vary in any material way between different manufacturers. Therefore, there is nothing unique about the PSRs in the Subject Vehicles. They are all manufactured by either Webasto or Inalfa. They are all manufactured using tempered glass. Any glass panel size differences between different vehicle models, and the method by which they are attached to the vehicle bodies, is immaterial because they all incorporate large, flat pieces of tempered glass that fail in the same manner.

- In his report, Dr. Verghese discussed his May 18, 2018 inspection of a 2016 Lincoln MKZ with a fractured panoramic sunroof belonging to someone named Paul Howd. Although this inspection of a non-Subject Vehicle model took

place during the pendency of this litigation, I understand Plaintiffs' counsel was not made aware of this inspection or of the existence of this vehicle, nor was it offered to me for inspection. The inspection that Dr. Verghese described in his report did not comport with established and accepted scientific standards. Unsurprisingly, his observations revealed nothing more than the reality of real-world driving conditions. In the real world, panoramic sunroofs can experience damage from "rock strikes or other impacts," that can cause "chips in the PSR glass." These strikes will cause progressive failure that will eventually lead to total destruction of the glass. And, as Dr. Verghese admits, PSR glass fractures "can occur from progressive crack growth over some period of time." This is a potential consequence existing in all tempered glass that makes it unsuitable for use in PSRs. Thus, his observations actually support, rather than disprove, my opinions.

- The Sarbacane test that Dr. Verghese performed is not representative of the type of damage that can occur in the real-world driving environment and is therefore unreliable.

- Dr. Verghese has yet to perform a legitimate glass failure analysis, consistent with t acceptable scientific methodology, on any of the PSRs in the Subject Vehicles.

- In his report, Dr. Verghese identifies minor damage to the paint and steel in one of the Subject Vehicles that he assumes resulted from strikes by road debris, but which did not result in shattering of the PSR. Dr. Verghese's opinions in this regard support my opinion that tempered glass is an inappropriate replacement for more reliable steel roofs. In fact, any one of the damage events to the steel roof that Dr. Verghese examined can lead to progressive failure of the PSR, shattering instantaneously if the crack reaches the area of tension. That would not happen with a steel roof.

- Contrary to Dr. Taylor's opinion, my report focuses on the fact that the PSRs are exposed to an infinite number of environmental factors (that may include rocks and other road debris), which are part of real-world driving conditions, and which can cause the PSRs in the Subject Vehicles to shatter. As I testified during my deposition, which was taken before Dr. Taylor's report was completed, there is an infinite number of damage events that can occur to a panoramic sunroof, which can include events such as a minor impact from road debris or simply dragging a rag with grit on it over the sunroof glass. Any of these events can scratch the compressive layer of the panoramic sunroof and eventually lead to the problem common to all PSRs manufactured with tempered glass panels—catastrophic failure of the glass. This is what Ford and its experts have failed to understand. When designing a product incorporating tempered glass for use as a PSR, Ford's engineers

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case and my extensive, first-hand knowledge and examination of PSRs identical to those used in the Subject Vehicles, it is my opinion that fully thermally tempered safety glass is an inappropriate and dangerous application for a PSR. Ford's incorporation of PSR assemblies manufactured by Webasto and Inalfa that use fully thermally tempered safety glass constitutes a safety defect common to all the Subject Vehicles.

1. <u>All Tempered Glass is Subject to Rapid and Total Destruction</u>

A. <u>Tempered Glass Failure</u>

Thermal tempering is the process of adding surface compression to glass making it stronger[2]. Glass tempering was devised to put the surface of glass in compression. The compressive stresses must be overcome before the glass surface can be put into tension, but once that happens the glass fails catastrophically.

As discussed in detail in my initial report (also discussed in the Verghese report), thermally tempered glass (in this report "tempered glass") has a compressive layer on the two faces (See Figure #1).

[2] In my initial report, I provided a detailed analysis of glass failure analysis and how it applies to the PSRs. I have reiterated some of that information here to further support of my rebuttal opinions.

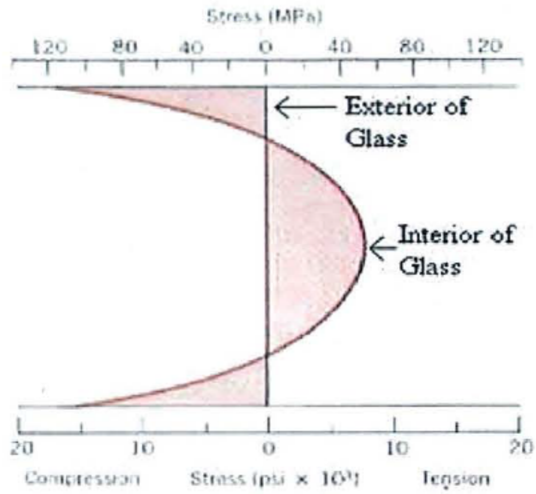

Figure #1: Stress profile of thermally tempered glass.

Fully tempered glass has a minimum surface compressive stress of 10,000 psi. This stress is balanced by tensile stresses in the interior. It is important to note that the compressive stress drops off exponentially from the surface. For properly tempered glass, the point of zero stress is at 20% of the thickness.

I performed an examination of tempered glass in order to show that the compressive stress drops and goes tensile near the edge of the glass. As shown below, I tested the stress near the edge of a tempered glass sample with a GASP (grazing angle surface polarimeter) by moving it to the edge of the tempered glass plate. This test showed that inside the glass it is 17,000 psi, and that it goes to zero psi near the edge.

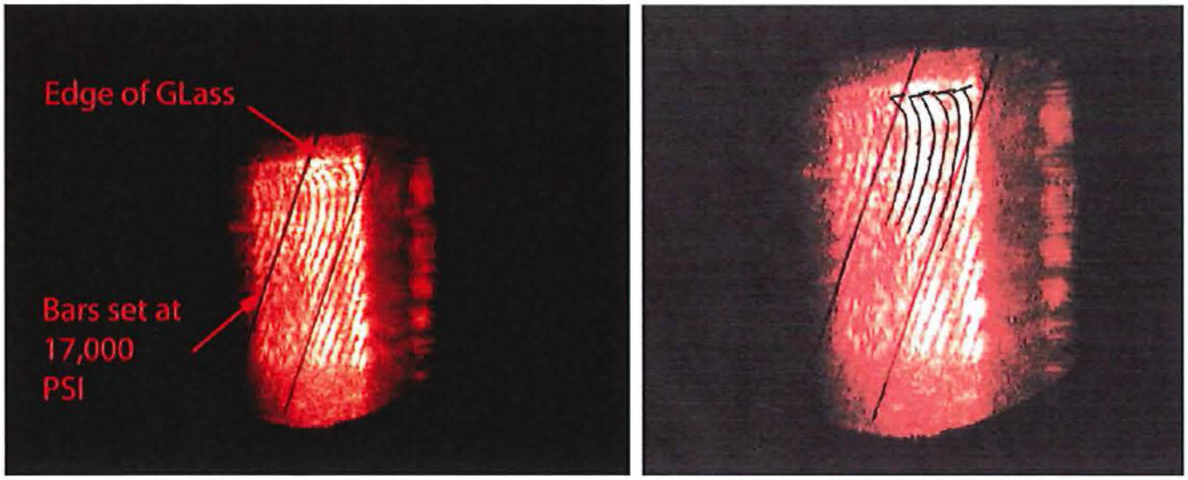

Figure #2: GASP measurements near the edge of a tempered glass panel. The GASP uses fringes to measure the surface stresses of tempered glass. One can see that direction of the fringes changes at the edge.

The GASP measurement shows that the compressive stress lessens as one moves toward the edge of the glass plate, and the area near the edge has very low or no compressive stress. Naturally, this means that the core tensile stress is increasing closer to the glass surface at the edge, which makes the glass more vulnerable to damage and self-destruction as glass only fails in tension.

As stated in my previous report, because stresses are additive for glass that has surface compression, the residual surface compressive stresses need to be overcome before the surface can be put in tension. Both glass science and common sense dictate that when the compressive stress is significantly reduced (here zero or close to zero near the edge), , the residual surface compressive stress (if any) can be easily overcome by the tensile stresses, causing the glass to self-destruct. This is important because tempered glass, like all glass, only fails in tension, and once the

applied tensile stress overcomes the compressive stresses, the glass fails catastrophically.

As a further example of glass failure, if the inherent strength of glass is 2000psi and it is fully tempered, the resulting strength is 12,000 psi. Thus, it is said that tempering strengthens the glass. However, as described herein, if the compressive layer is penetrated, the tempered glass "self destructs." Cracks driven by the interior tensile stresses travel throughout the glass part at 36,000 mph (to the observer, the glass "explodes"). It's as if the glass object dissappears.

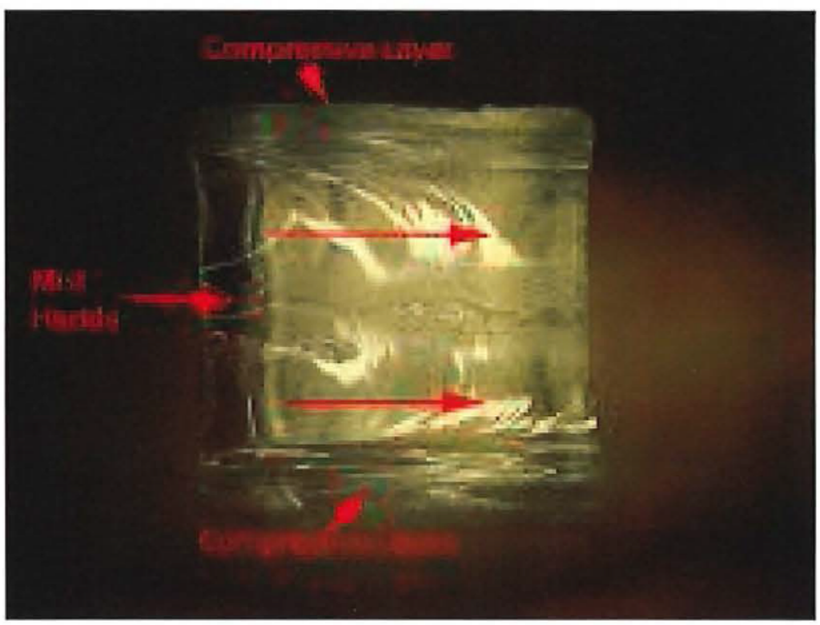

Figure #3: Representative fracture surface created when a fully tempered glass object fails. The mist hackle at center thickness indicates that the crack is traveling at its maximum velocity (3600mph).

Automobile manufacturers, such as Ford, must be aware that all tempered glass is capable of total self-destruction, which occurs at a maximum velocity of

3600mph. This speed will inevitably cause catastrophic failure of the glass. This is the defect—the use of tempered glass in PSRs is an improper application for that type of glass.

There are two stages to tempered glass failure, which applies to all tempered glass, including the PSRs in the Subject Vehicles: Fracture Initiation and Crack Propagation.

1. Fracture Initiation: The first stage of tempered glass failure is fracture initiation. The fracture initiation could be direct impact where at the moment of damage the compressive layer is penetrated and the interior tensile stresses take over and drive the cracks. The initiation can also be the start of a progressive failure; in this case there is minor damage due to impact from something like a small rock or scratching either in assembly or by the vehicle owner or occupant, as described herein. In these cases, environmental factors (i.e. normal operation of the vehicle) will cause this initial damage to grow until it penetrates into the tensile region and causes the glass to self-destruct.

2. Crack Propagation (Unique to tempered glass): The second stage of tempered glass failure is crack propagation. Once the failure initiates, the interior tensile stresses drive the initial crack, and the failure is instantaneous at 36,000 mph, causing the glass to essentially vanish.

B. Damage to Laminated Glass:

In comparison to tempered glass failure, surface damage to laminated glass will cause chipping, but will not cause the glass to spontaneously shatter. Below are examples of damage to the windshield of the Beaty vehicle near the PSR, which caused chipping but not spontaneous shattering.

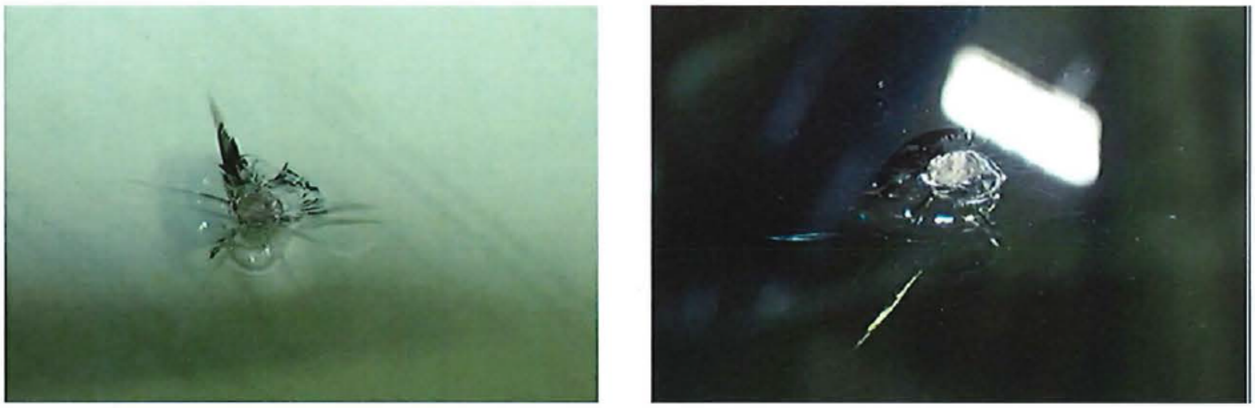

Figure #4: Part of Figure 11 from the Verghese report.

The windshield has a more vertical orientation than the PSR, so the impact is direct and almost perpendicular to the glass. It is important to note that the glass has chipped, but it did not self-destruct. Although tempered glass is stronger, it cannot survive damage that penetrates the compressive layer.

C. Damage to Painted Steel: Steel fails in very different ways than tempered glass. Steel does not self-destruct from surface impacts. Below are examples of chips in the roof paint adjacent to the rear PSR glass (Figure #11 of Verghese report). Here the steel can absorb impact events without self-destructing. The impact merely chips the paint.

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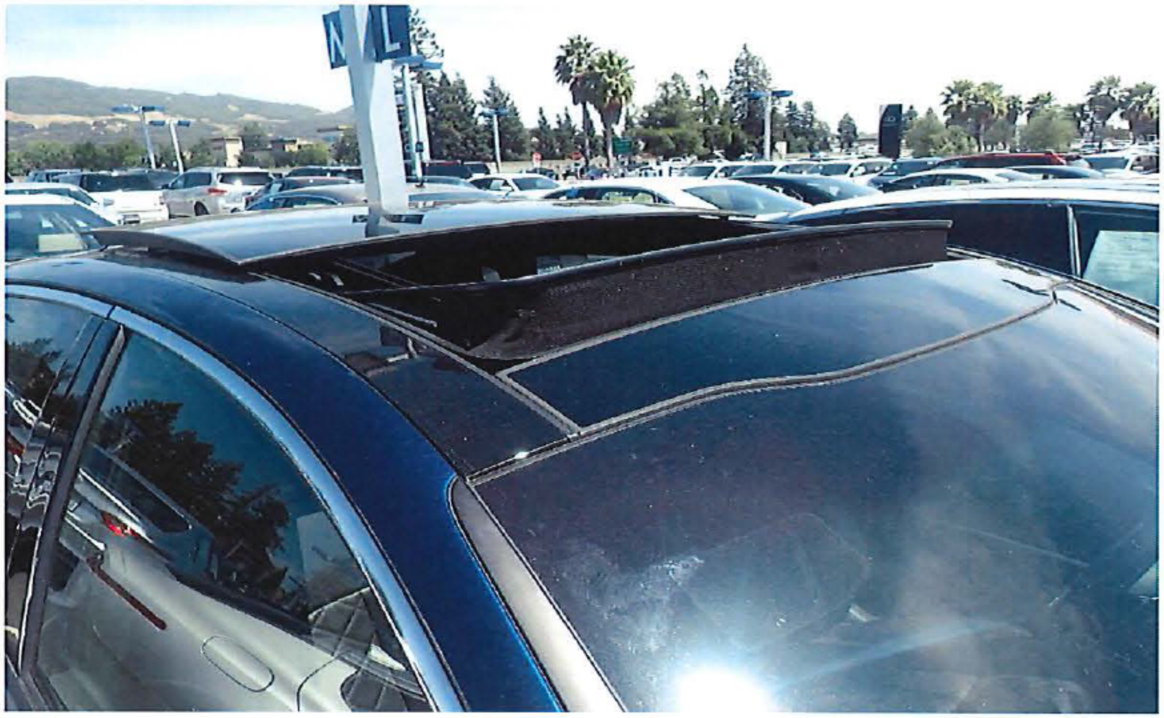
because, as shown in the pictures below, on June 24, 2019, I went to a Carmax dealership and personally examined and operated the PSRs in several of the Subject Vehicle models. I also looked at several Kia vehicles I know to have been manufactured with PSR assemblies from Webasto and Inalfa to compare the PSRs.

2017 Ford Edge

2016 Ford Explorer Limited

2016 Ford Explorer Limited



2016 Kia Optima

2016 Kia Optima

My inspections of all of these vehicle models and PSRs confirmed that they are materially the same as the Subject Vehicles. Thus, I have examined numerous PSRs that are the same as those included in the Subject Vehicles, and it remains my opinion that the PSRs in the Subject Vehicles, which are manufactured with tempered glass, are defective and that this defect is common to all of the Subject vehicles.

Further, there is nothing unique about the installation of the PSRs in the Subject Vehicles, which is identical in all material respects to PSR applications I have previously examined, and which I also personally observed in the Ford Subject Vehicles on June 24, 2019.

As shown in Figure #6 below, each glass panel in the PSRs is affixed to the sunroof frame using a sealant or fasteners. The sunroof frame is affixed to the vehicle frame via fasteners. It is my understanding that these vehicles utilize a unibody construction which means that the entire body of the car, including the sunroof, handles and absorbs the loads and stresses applied to the vehicle.

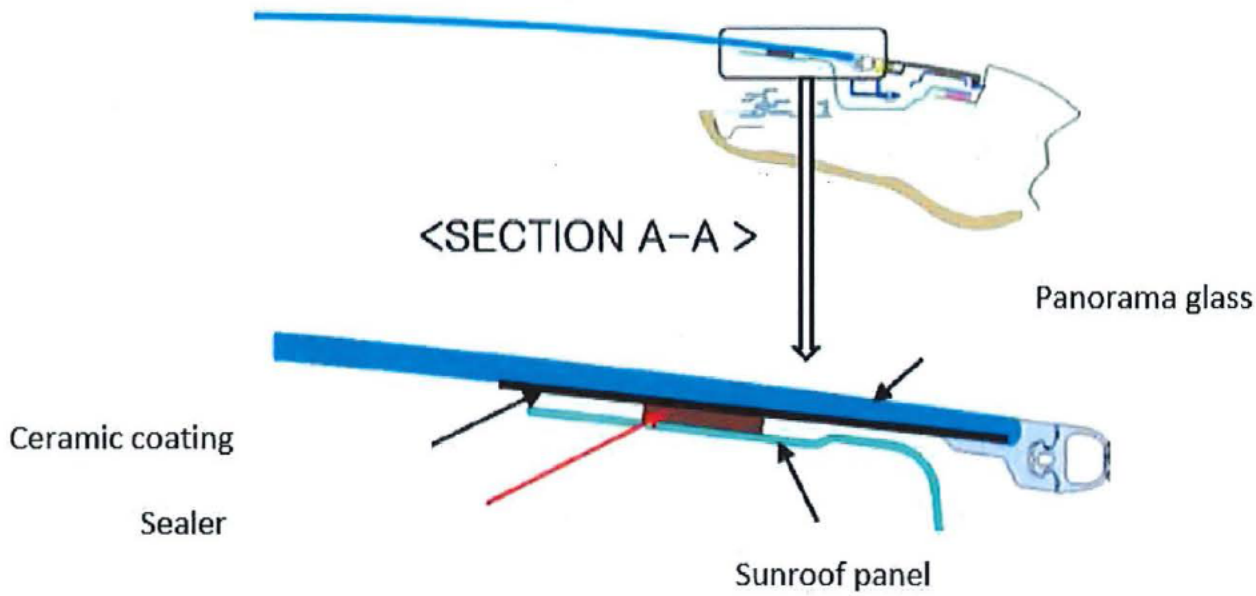


Figure 6: PSR Attachment

3. Tempered Glass Failure Characteristics (Including the Defect) Are Common to All PSRs.

Tempered glass is considered "safety glass" because when it breaks, it rapidly breaks into small glass "cubes." Tempered glass shatters into small fragments that are intended to prevent the possibility of serious injury, but which may still have sharp edges. Eikey Deposition p. 187. All modern automobiles have tempered side and back windows. In contrast, the windshield is made of laminated glass, which consists of two pieces of annealed glass laminated together with a plastic sheet. As described above, damage to the laminated glass does not cause it to instantly shatter into loose fragments like tempered safety glass.

For purposes of this litigation, the problem with using tempered glass in PSRs is twofold. *First*, unlike a steel roof, the glass PSRs cannot withstand the

environmental stresses encountered under ordinary driving conditions when they become scratched or chipped. The most prevalent manifestation is shattering caused by the progressive expansion of a crack, scratch or chip in the compressive layer of the glass. Once this progressive expansion reached the tensile layer of the glass, it fails instantaneously by shattering into thousands of fragments as it is design to do. *Second*, unlike with side or rear windows, the PSR fragments can, and do, rain down into the cabin of the Class Vehicle. Dozens of complaints made to NHTSA involving PSRs manufactured by Webasto and Inalfa describe the consequences of shattering events. *E.g.*, Complaint ¶ 34. They occur when the vehicle is moving in traffic, moving isolated from other vehicles, stopped at a traffic control device, or parked in or outside of a garage. *Id.* While it is true that some small pieces of glass might spall off, laminated glass (that Ford does use in some of its PSRs) does not result in a cascade of fragments raining down in the cabin of the vehicle. And of course, a steel roof will not shatter at all.

Dr. Verghese states that one must examine each failed Ford PSR in order to render an opinion as to the cause of failure (i.e. each failure is unique). Why any particular PSR failed is irrelevant. It does not matter if the origin was at one point in one PSR and at another point is a different PSR. The relevant consideration is that, as indicated in my initial report, given the size, thinness, curvature, ceramic frit, and attachment to the unibody frame, the PSR glass in the Subject Vehicles is not capable

of withstanding the tensile stresses (or "applied loads") as Dr. Verghese uses the term) one would reasonably anticipate under ordinary driving conditions, making the glass defective in that it is substantially likely to shatter and not reasonably fit for its intended use and environment. In other words, the PSRs in Subject Vehicles will likely experience glass shattering in connection with the tensile stresses discussed herein. It is important to note that the PSR is replacing a steel roof that is completely reliable.

The defect is even more dangerous given that the thickness of compressive stress is significantly reduced near the edge, making it more vulnurable to surface damage. Most glass failures, including those in panoramic sunroofs, initiate as surface flaws. Thus, even a minor event can cause surface damage, which can disrupt the compressive layer. For example, with a panoramic sunroof, dragging a wedding ring over the glass, grit from a cleaning rag used on the glass, or car keys being thrown in the car and hitting the glass can cause surface damage. The possibilities are infinite, and any mechanical process that leads to penetration of the compressive layer will cause the glass to fail completely. Thus, the actual cause of any individual abrasion, chip, scratch, or crack is immaterial. The fact that the PSR's glass fails during ordinary driving conditions because these surface various flaws is the relevant point.

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As described in my initial report, generally, two steps can be taken to perform glass failure analysis, including:

a. Glass Failure Analysis Stage #1: When possible, assemble the glass pieces to determine the overall crack pattern. Often the crack pattern guides one to the approximate location of the origin. In this case (i.e., tempered glass) the crack pattern initiates at one point and radiates outward (similar to the spokes on a bicycle wheel).

b. Glass Failure Analysis Stage #2: Stage two is to use markings on the fracture surface (the surfaces created during failure) to trace the cracks back to the "failure origin" and then examine the origin microscopically to determine what led to the failure. Normally, Wallner lines (defined below) on the fracture surface are used for this purpose.

Wallner lines are sets of curved marks that all emanate from the origin. By examining the direction of the curvature of the lines, one can trace backward along the fracture surface to the origin. Tertiary Wallner lines are caused by elastic pulses generated from outside the crack front (Failure Analysis of Brittle Materials, V. D. Frechette, American Ceramic Society (1990) ISBN 0-944904-30-0;: page 17). In other words, Wallner lines are formed as a result of an interaction of the moving

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of the Howd vehicle. However, even from the description and few photographs of the Howd vehicle contained in Dr. Verghese's report, I am able to conclude that he failed to conduct a proper and complete glass failure analysis. If he had, it likely would have shown that the glass fracture was caused from progressive, and not immediate, failure. To date, Dr. Verghese has yet to demonstrate that he has conducted a legitimate failure analysis on a PSR in any of the Subject Vehicles (contrary to my experience, which involves multiple glass failure analyses of PSRs that are materially identical to those in the Subject Vehicles).

The pictures that Dr. Verghese presented of the Howd vehicle show that the fracture had to fail in a progressive manner because, as shown below, the scuffing that occurred to the Howd vehicle could not cause immediate failure. In order to assess the evaluation that Dr. Verghese performed on the Howd vehicle, I conducted a test involving damage to tempered glass from a stone traveling at an approximate 30-degree angle in excess of 85 mph, which shows scuffing damage to the glass that is similar to the scuffing that occurred to the Howd vehicle.

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Dr. Verghese concludes this damage shows the fracture origin and an immediate fracture. However, Dr. Verghese failed to perform a proper and complete glass failure analysis to confirm his conclusion that this failure occurred immediately upon impact. In particular, Dr. Verghese never exposed the fracture surface to determine the cause of failure. Instead, he appears to have simply taken pictures of the PSR.

As stated herein and in my previous report, in order to perform a proper glass failure analysis, the pieces at the origin must be removed to expose the fracture surface, and the origin should then be analyzed microscopically to determine the cause. Notably, Dr. Verghese could have easily done this as the PSR glass in the Howd vehicle was intact with a layer of plastic beneath the glass, which would have allowed Dr. Verghese to determine exactly how the crack moved.

Had Dr. Verghese performed a complete glass failure analysis, the conclusion would have likely been that the complete fracture of the glass did not occur at the moment of impact, as shown in my testing in Figure 8 above. Instead, the scuffing would have simply caused a crack that would have continued to progress and cause instantaneous fracture once it penetrated to the tensile layer.

More importantly, Dr. Verghese's observations simply reveal the reality of real-world driving conditions that are the basis of the defect in this case. In the real world, panoramic sunroofs can experience damage from "rock strikes or other

impacts," that can cause "chips in the PSR glass." These events frequently cause progressive failure that will eventually lead to total destruction of the glass, such as those shatter events described in the NHTSA complaints, in numerous news reports, and elsewhere. And, as Dr. Verghese is forced to admit, PSR glass fracture "can occur from progressive crack growth over some period of time." Thus, his findings actually support, rather than disprove, my opinions.

To further demonstrate my point, the below figures shows a progressive failure as a result of initial damage being driven into the glass by flexing and thermal shock. As stated in my previous report, these are environmental factors that occur during real-world driving, and are sources of tensile stresses applied to the panoramic sunroof glass. This shows that an initial damage event can grow progressively over time, as Ford's experts admit, and eventually cause catastrophic failure. Thus, once there is initial scuffing damage, with continued use of the vehicle, environmental stresses will cause the crack to grow to the point of catastrophic failure.

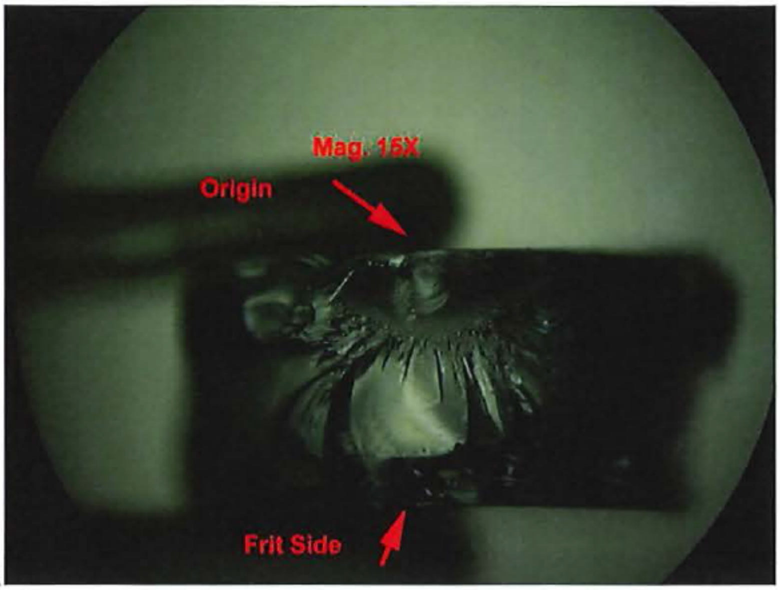

Figure #10: Photomicrograph of the origin of tempered glass oven door that was damaged with a diamond scribe and was then flexed and thermal shocked. The fracture originated on the side opposite the frit (i.e. the damaged side).

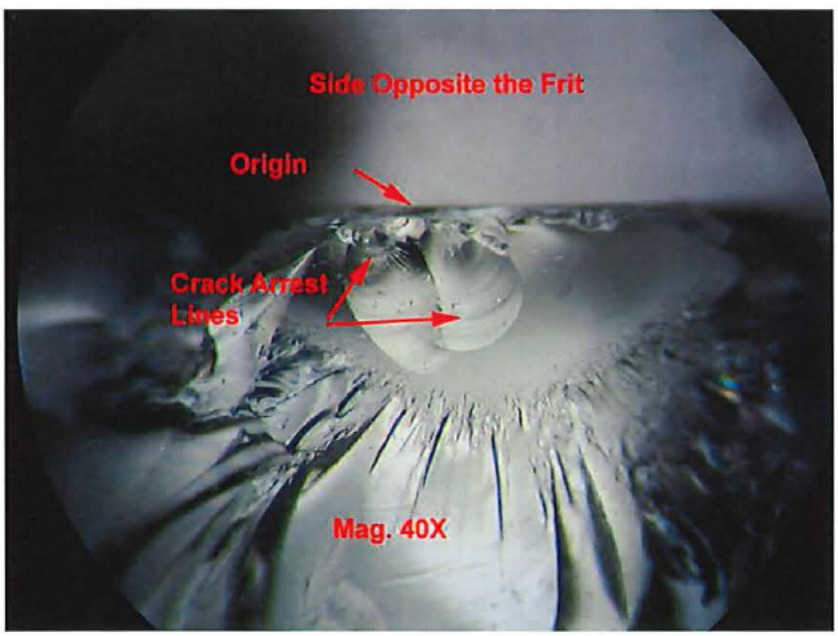

Figure #11: Higher magnification photomicrograph of the origin shown in Figure #10 above.

The damage origin in Figure s #9 and 10 have the same appearance as many of the failed PSRs manufactured by Webasto and Inalfa that I have examined in this and other cases. The glass did not immediately fail catastrophically at the point of impact, but will instead fail catastrophically from progressive growth over time.

VI. CONCLUSION

Given the size, thinness, curvature, ceramic print, and attachment to the unibody frame, the panoramic sunroof glass in the Subject Vehicles, thermally tempered glass is an inappropriate and dangerous application for a panoramic sunroof.

Dated: July 10, 2019

Thomas L Read

Thomas L. Read, PhD